



# JCAA/JG-PP No-Lead Solder Testing

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Workshop

September 22, 2004

# Status

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- Boeing Irving completed assembly of 205 test vehicles
- Vehicles distributed to testing sites on 7/19/04
- Testing
  - ✓ Boeing Seattle (thermal cycle\*, thermal shock, vibration)
  - ✓ Boeing Anaheim (SIR\*, electromigration\*)
  - ✓ Rockwell-Collins (thermal cycle)
  - ✓ ACI (mechanical shock, salt fog)
  - ✓ Raytheon (combined vibration/thermal cycle)
  - ✓ Sandia (microsections\*)

\*Donated as work-in-kind

# Boeing Testing (Seattle)

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- **Thermal Cycle (15 test vehicles)**
  - ✓ 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
- **Thermal Shock (30 test vehicles)**
  - ✓ 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
  - ✓ **(Reworked)** 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
- **Vibration (30 test vehicles)**
  - ✓ 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi
  - ✓ **(Reworked)** 5 – SnPb; 5 – SnAgCu; 5 – SnAgCuBi

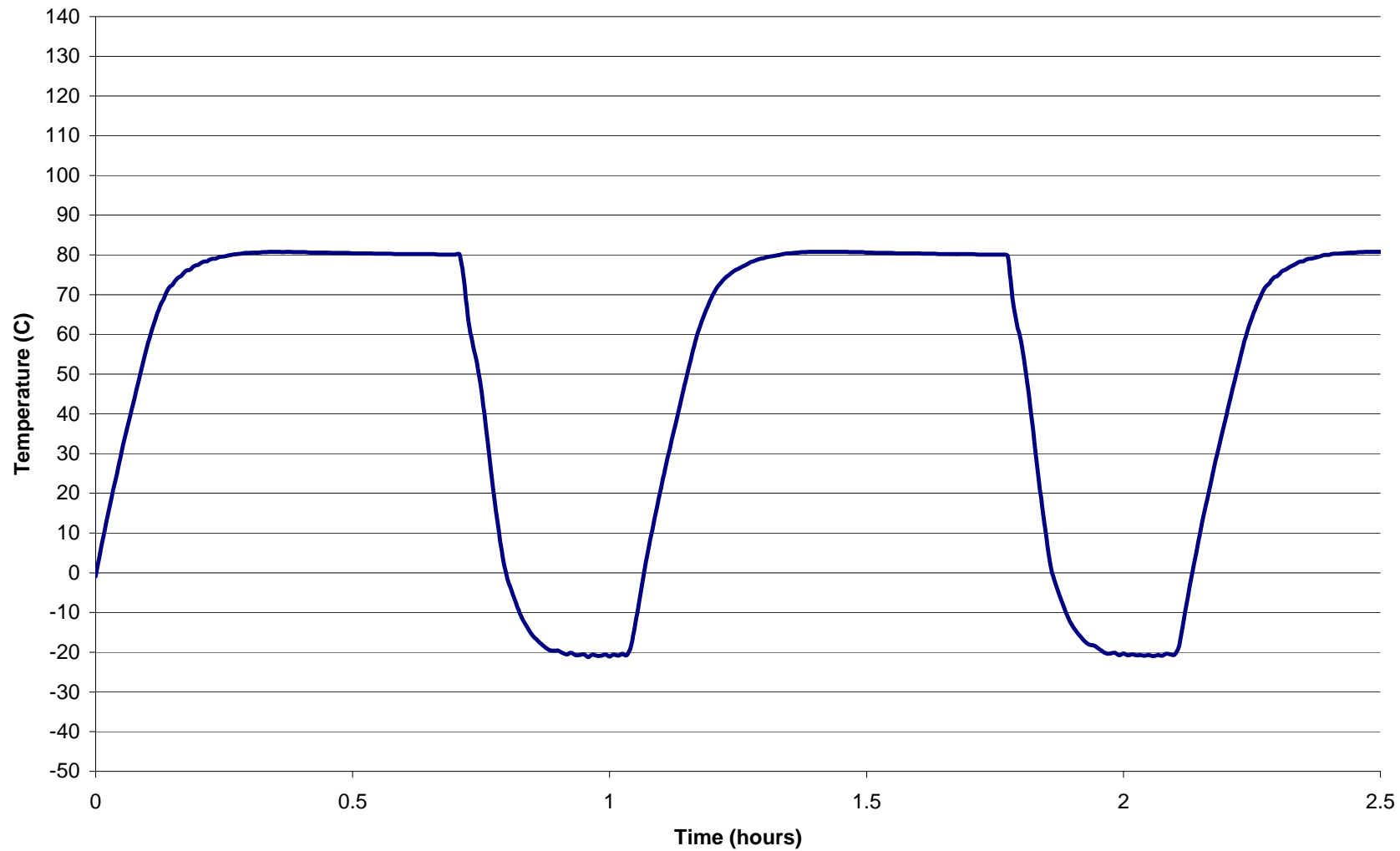
# Thermal Cycling - Boeing

(-20°C to 80°C)

# Thermal Cycle Chamber



**Thermal Cycle (-20°C to +80°C; Actual Board Temperature)**  
**30 min. dwell (hot); 10 min. dwell (cold)**



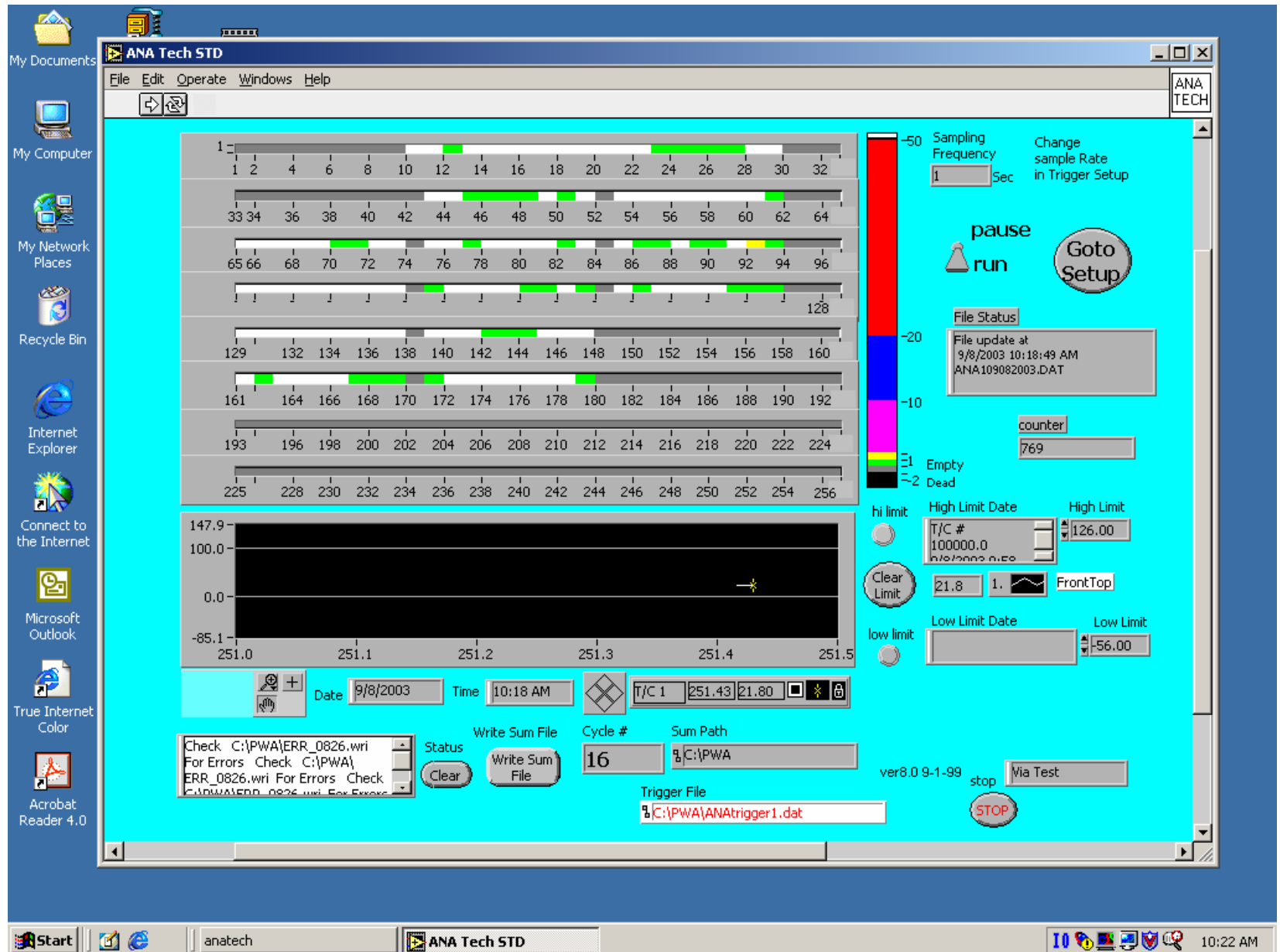


# Anatech Event Detectors

Up to 4 can be controlled by one computer for a total of 1024 channels



# Labview-based Data Collection Software



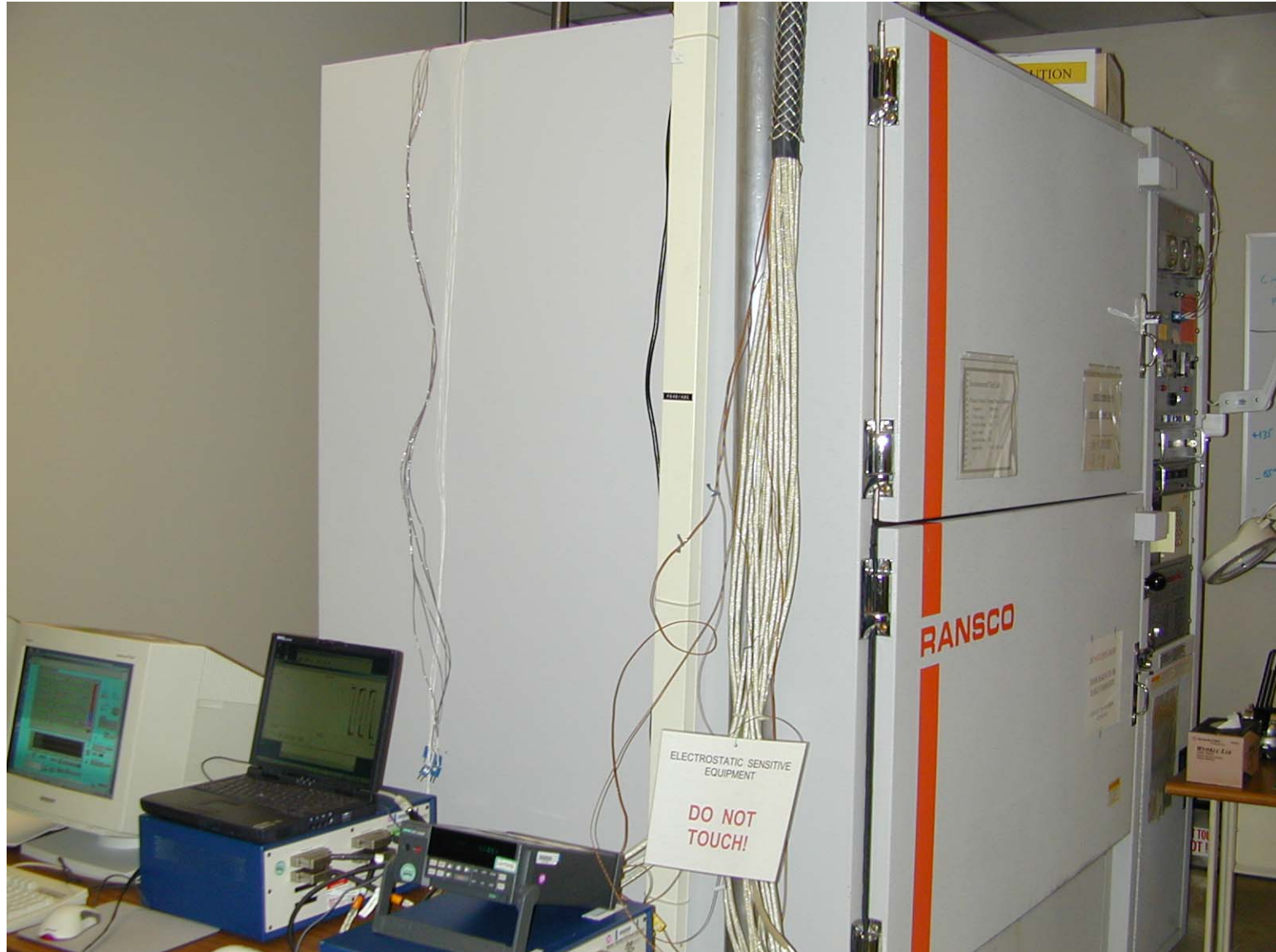


# Thermal Shock - Boeing

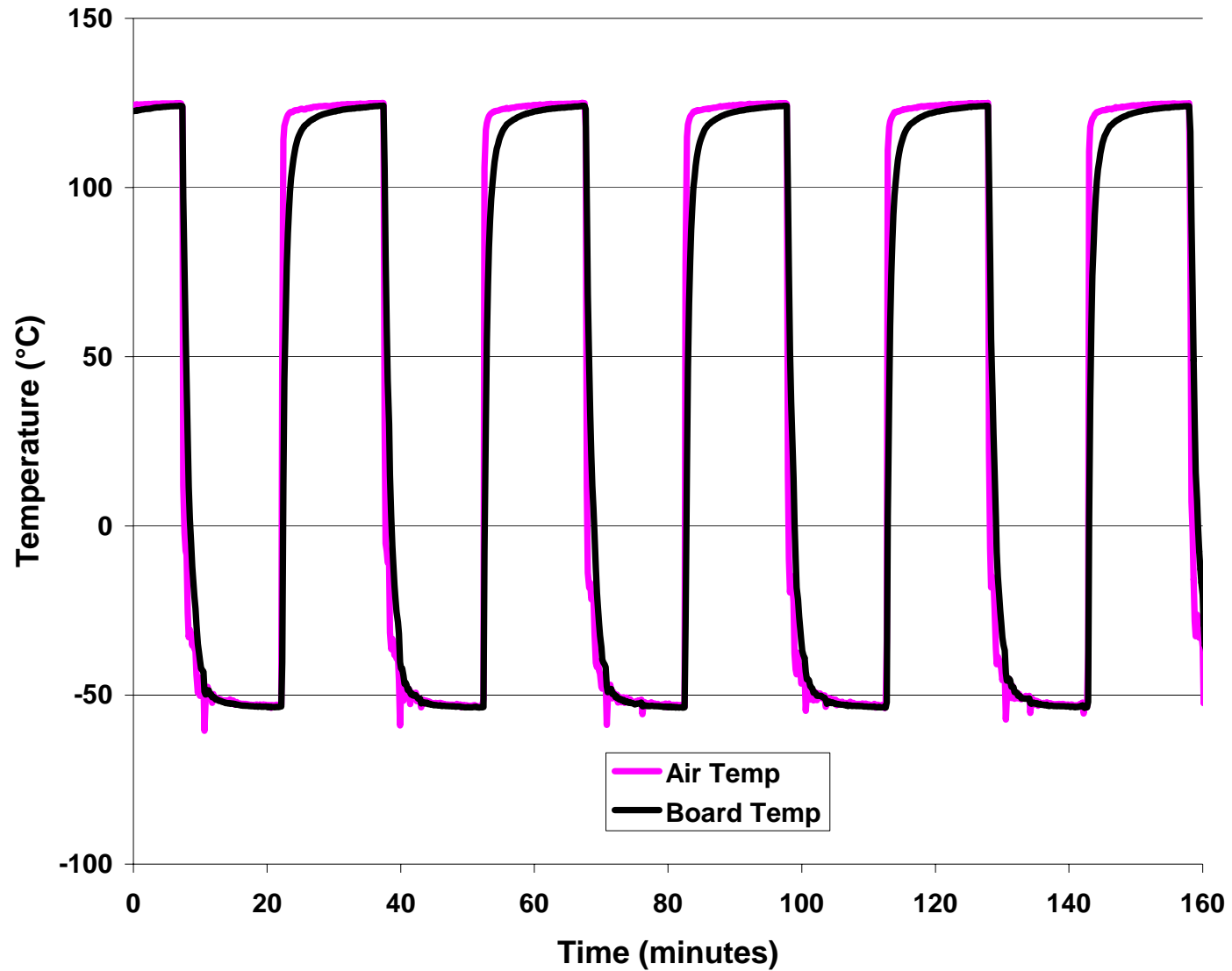
(-55°C to 125°C)

# Thermal Shock Chamber

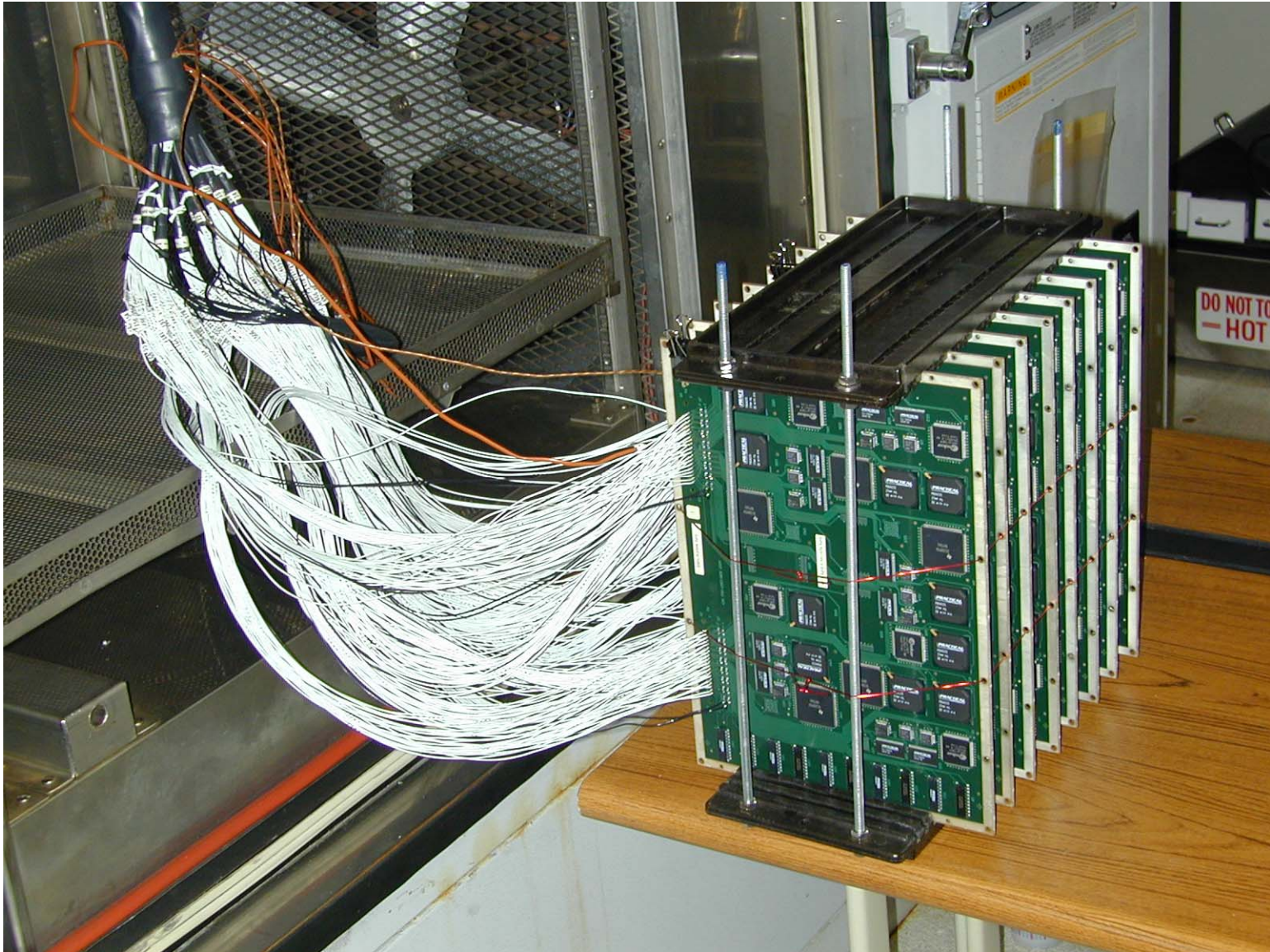
Capable of  $-70^{\circ}$  to  $200^{\circ}\text{C}$   
Wired for 512 Channels



## Thermal Shock Cycle (-55°C to 125°C, 15 min. dwells)

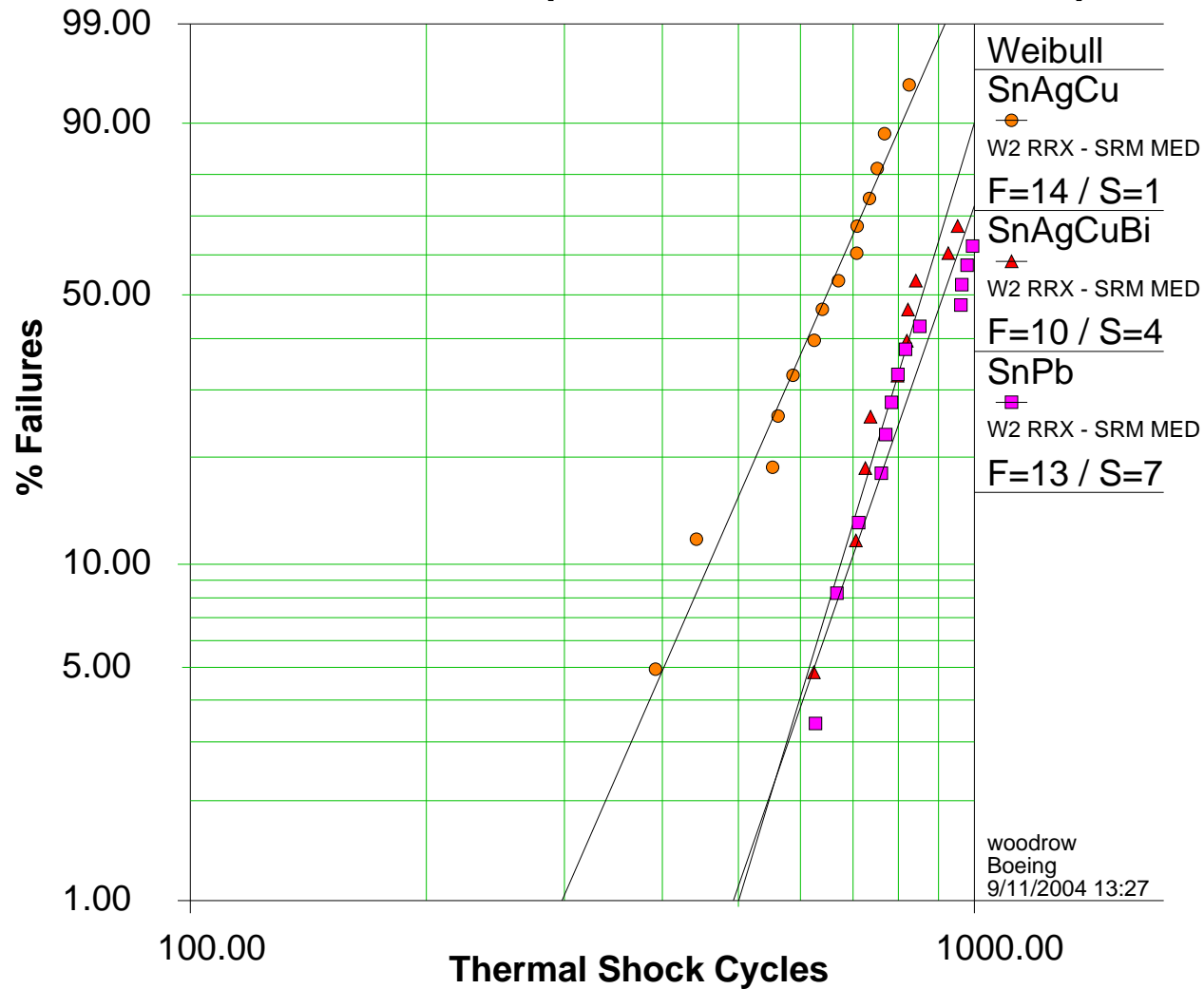


## Test Vehicles Ready for Thermal Shock Test





# CLCCs (Manufactured Boards)



$\beta_1=5.4468, \eta_1=692.9868, \rho=0.9882$   
 $\beta_2=7.8529, \eta_2=899.1317, \rho=0.9721$   
 $\beta_3=6.8595, \eta_3=963.3632, \rho=0.9571$

# Vibration - Boeing

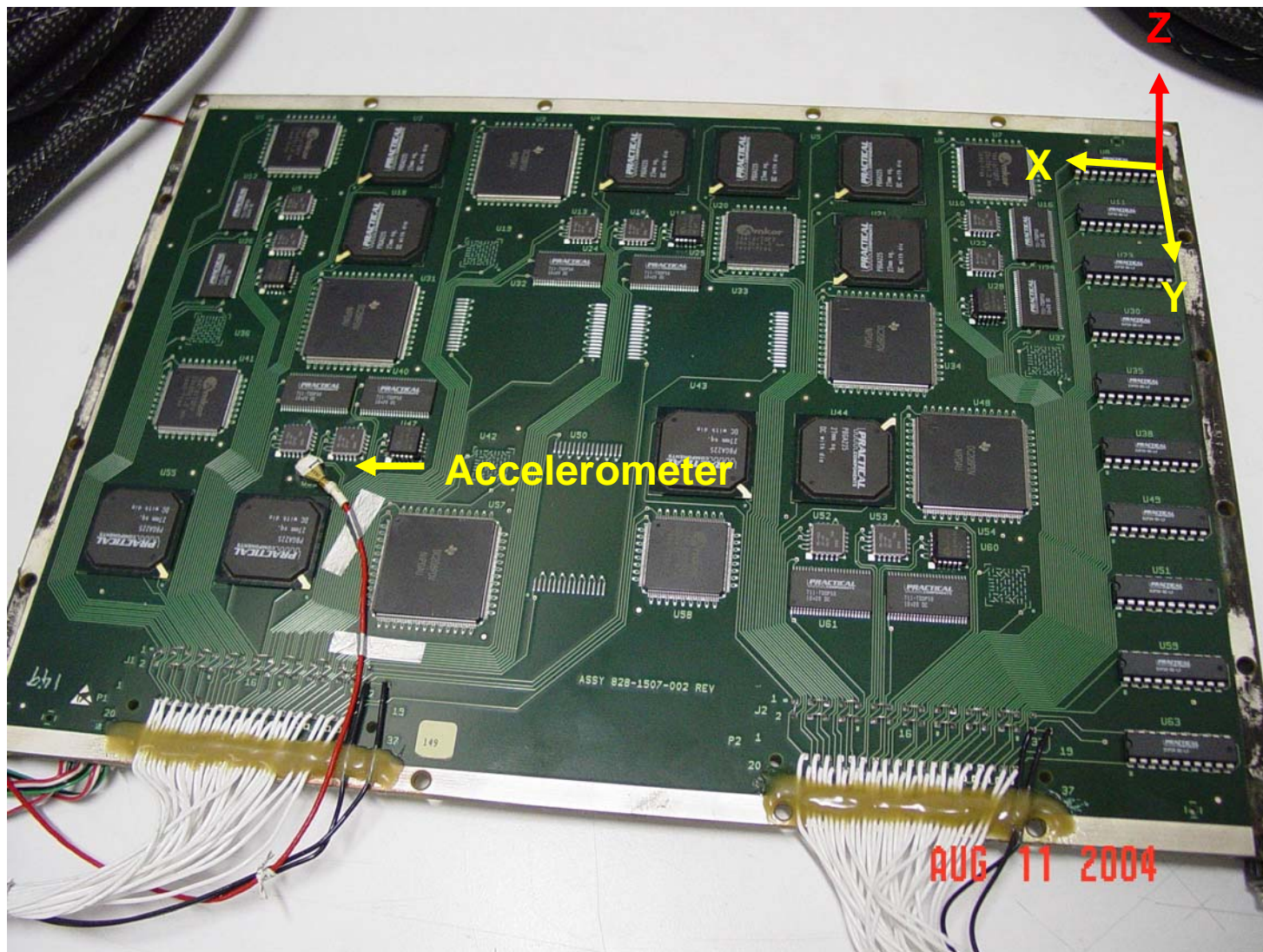
# Pathfinder Board

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- A “pathfinder” board was used:
  - ✓ To verify that there were no problems with electronic noise, the fixture, or the wires
  - ✓ A modal analysis was done using a laser vibrometer (maps mode shapes and identifies resonances)
  - ✓ A strain gauge was mounted on the “pathfinder” board so that CALCE would have strain data for validation of their models

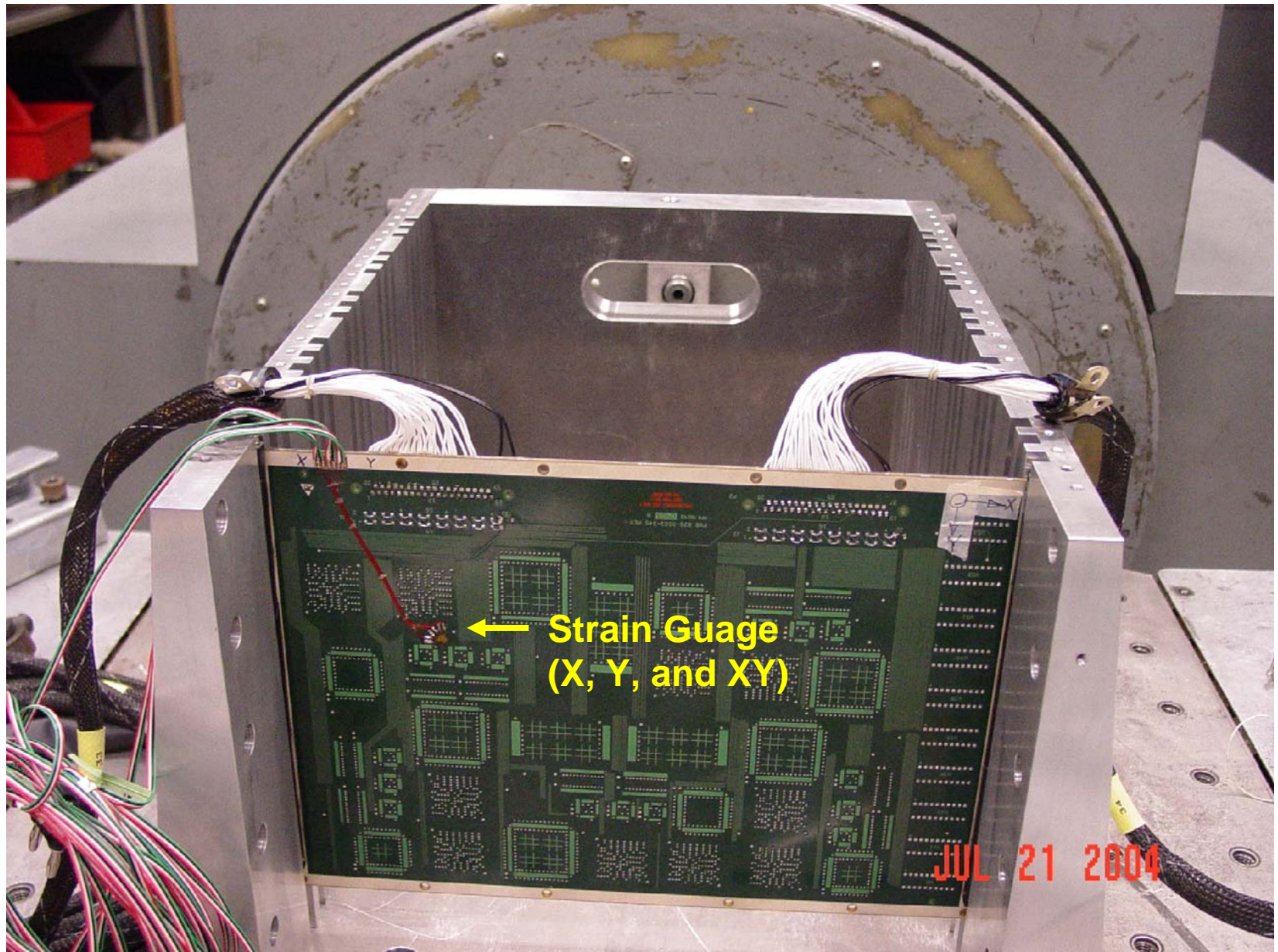


# Test Vehicle





# Strain data was taken for CALCE

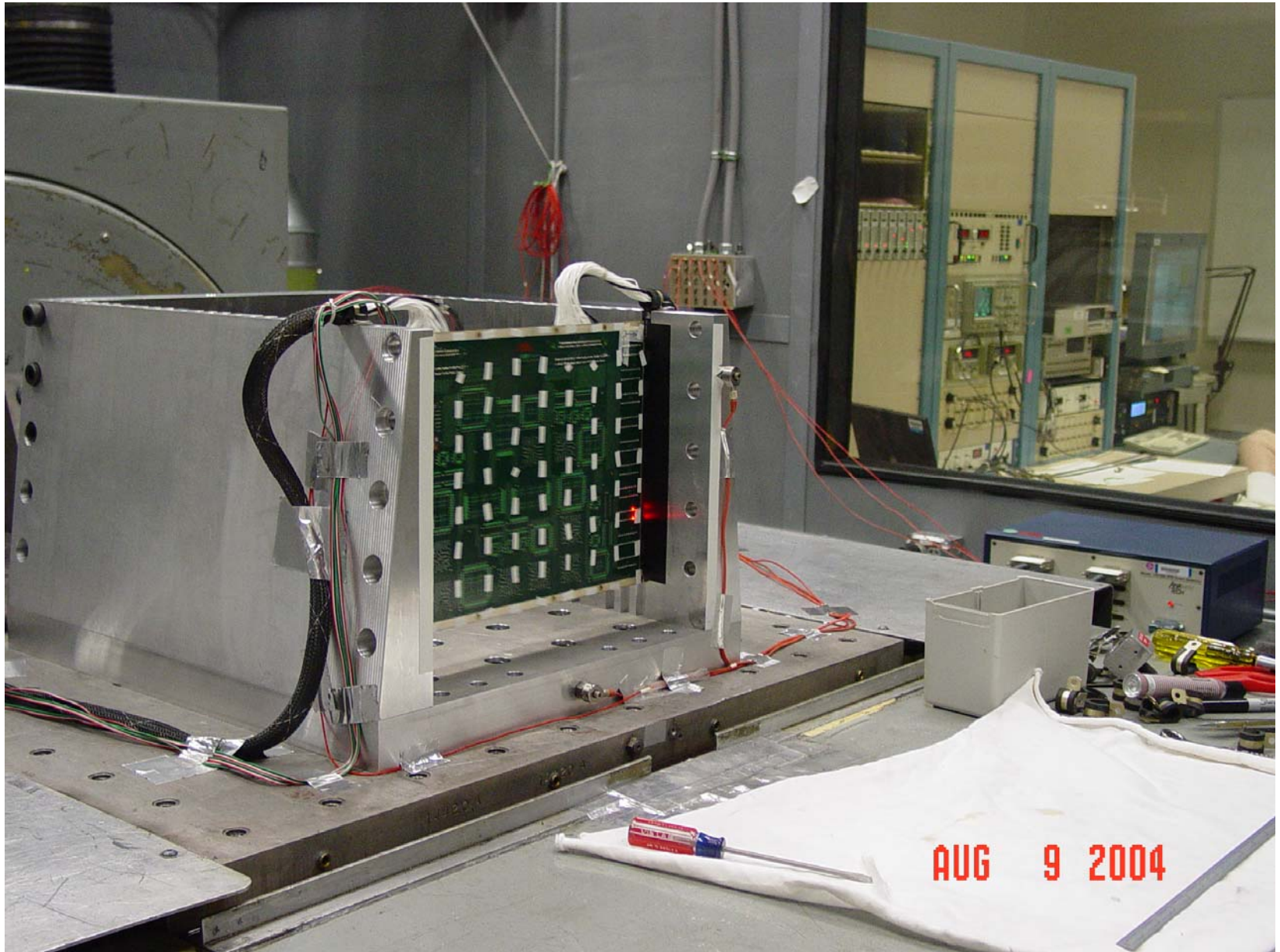




# Laser Vibrometer System for Modal Analysis of Test Vehicle



# Laser Vibrometer Measures Velocities, Accelerations, Displacements

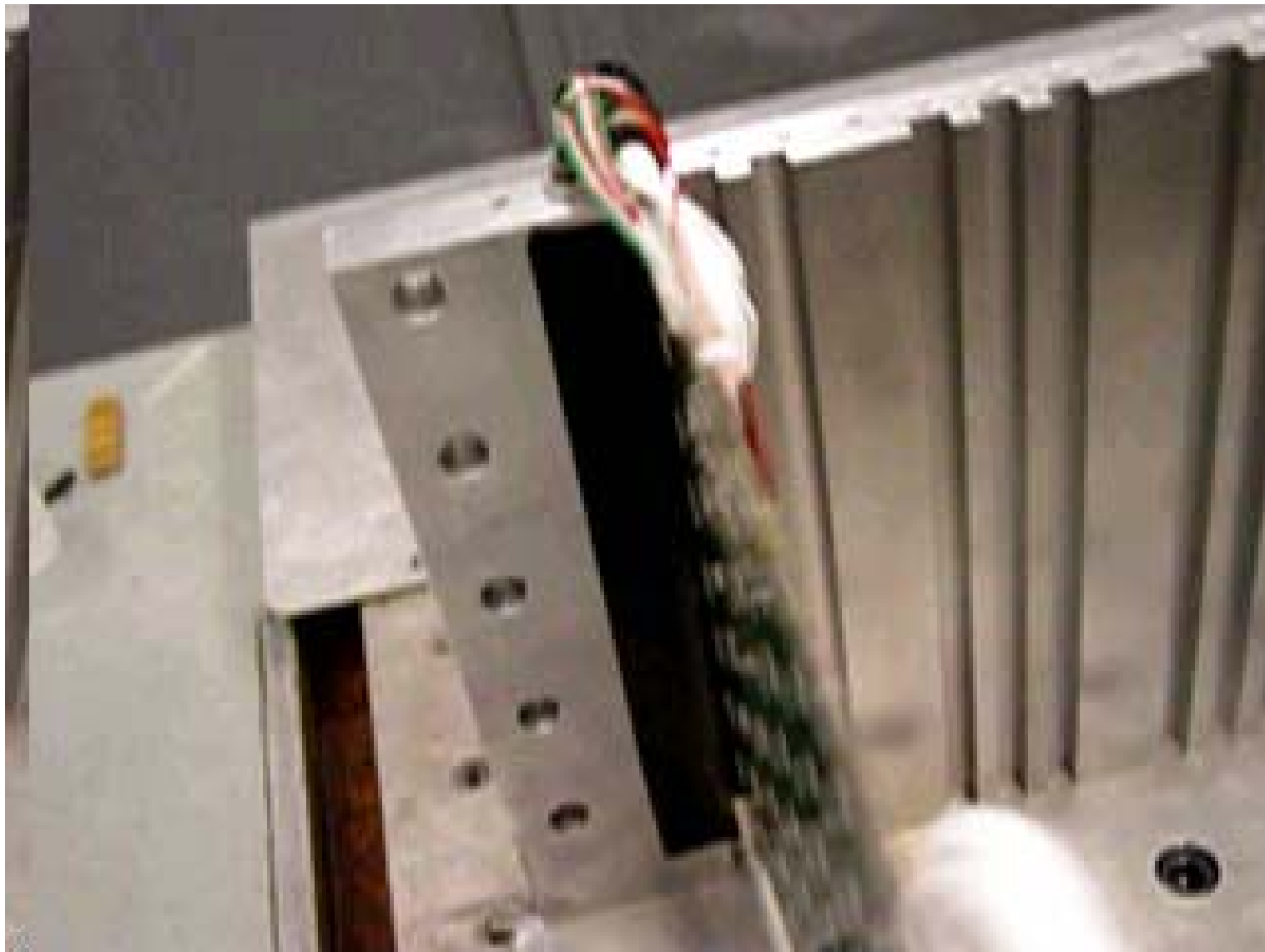




## Laser Vibrometer (Don Powers)



## Pathfinder Test Vehicle in Z-Axis (16.0 Grms)




# Operating Deflection Shape at 72 Hz


Domain **FFT**

Signal  
Vib & Ref1 FRF Velocity ...

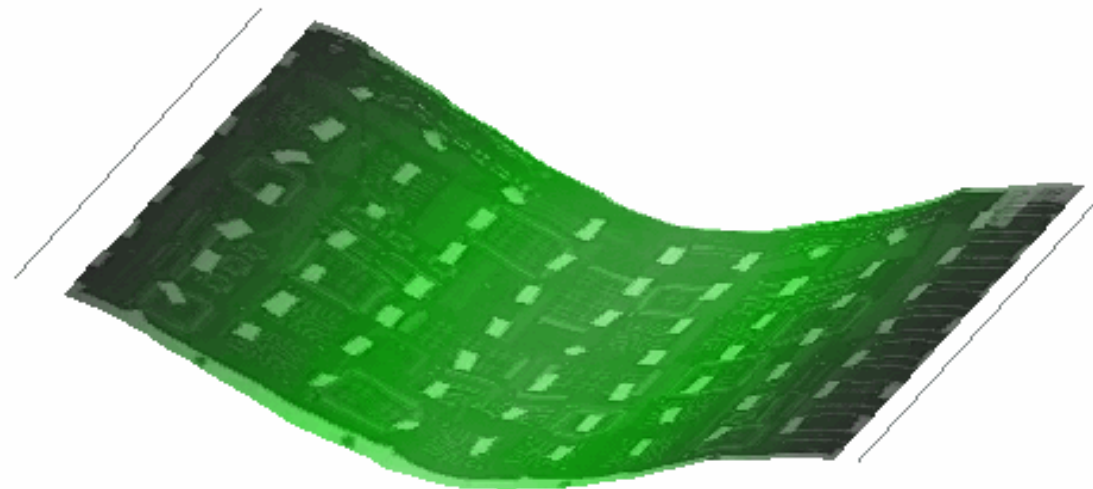
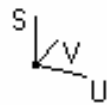
Inst. Value  
 $1e-3 \text{ m/s} / \text{m/s}^2$



Zoom 196 %



Lead Free Circuit Board Vibration Test - 72Hz Operating Deflection shape



Band 1 72.00 Hz  
Angle 0°




# Operating Deflection Shape at 101.5 Hz

Domain **FFT**

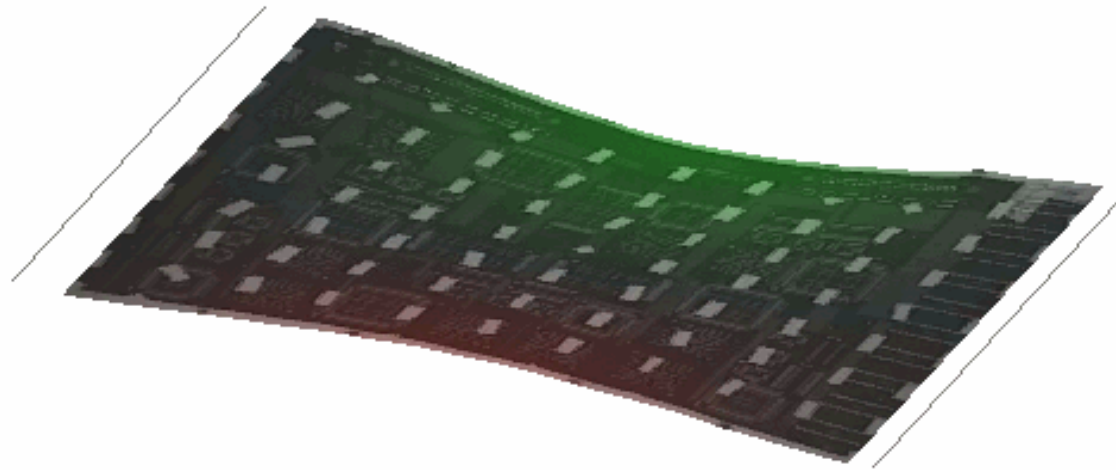
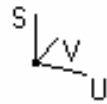
Signal  
Vib & Ref1 FRF Velocity ...

Inst. Value  
 $1e-3 \text{ m/s} / \text{m/s}^2$

Zoom 200 %



Lead Free Circuit Board Vibration Test - 101.5Hz Operating Deflection shape



Band 1 **101.5 Hz**


Angle **0°**

# Operating Deflection Shape at 411.5 Hz


Domain **FFT**

Signal  
Vib & Ref1 FRF Velocity ...

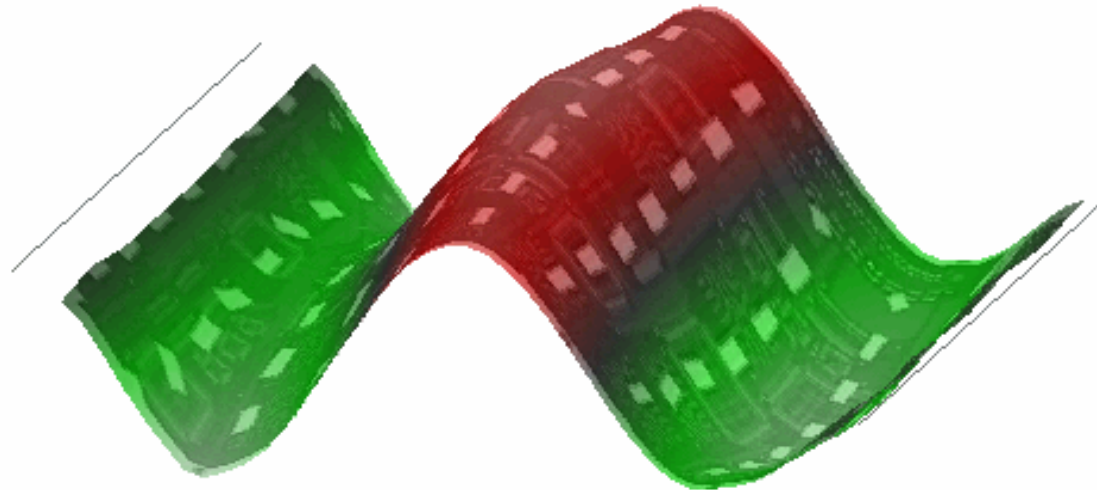
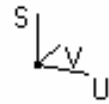
Inst. Value  
 $1e-3 \text{ m/s} / \text{m/s}^2$



Zoom 197 %



Lead Free Circuit Board Vibration Test - 411.5Hz Operating Deflection shape



Band 1 **411.5 Hz**

Angle **0°**

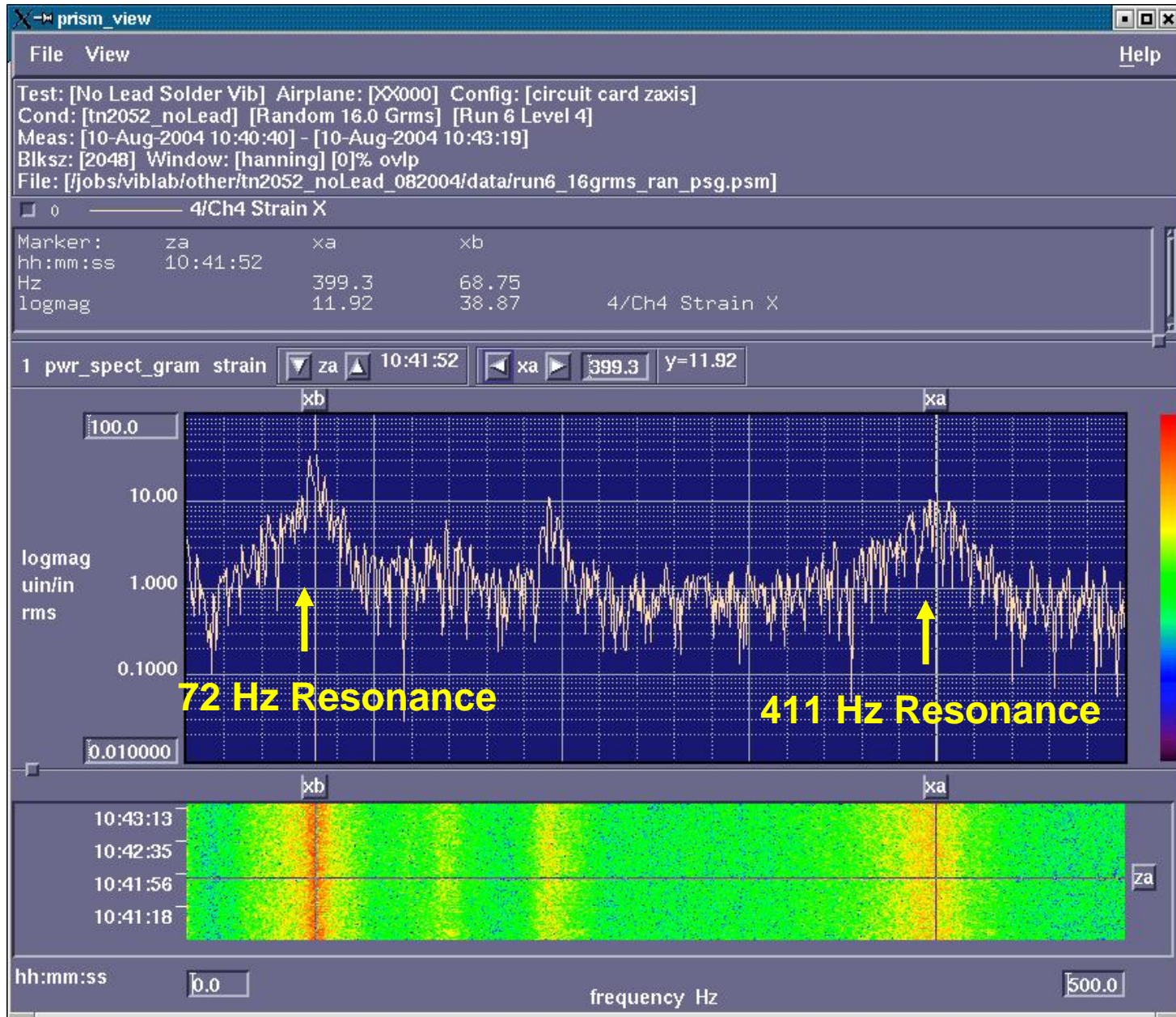
## Strain Acquisition using Prism (Tom Kowalski)



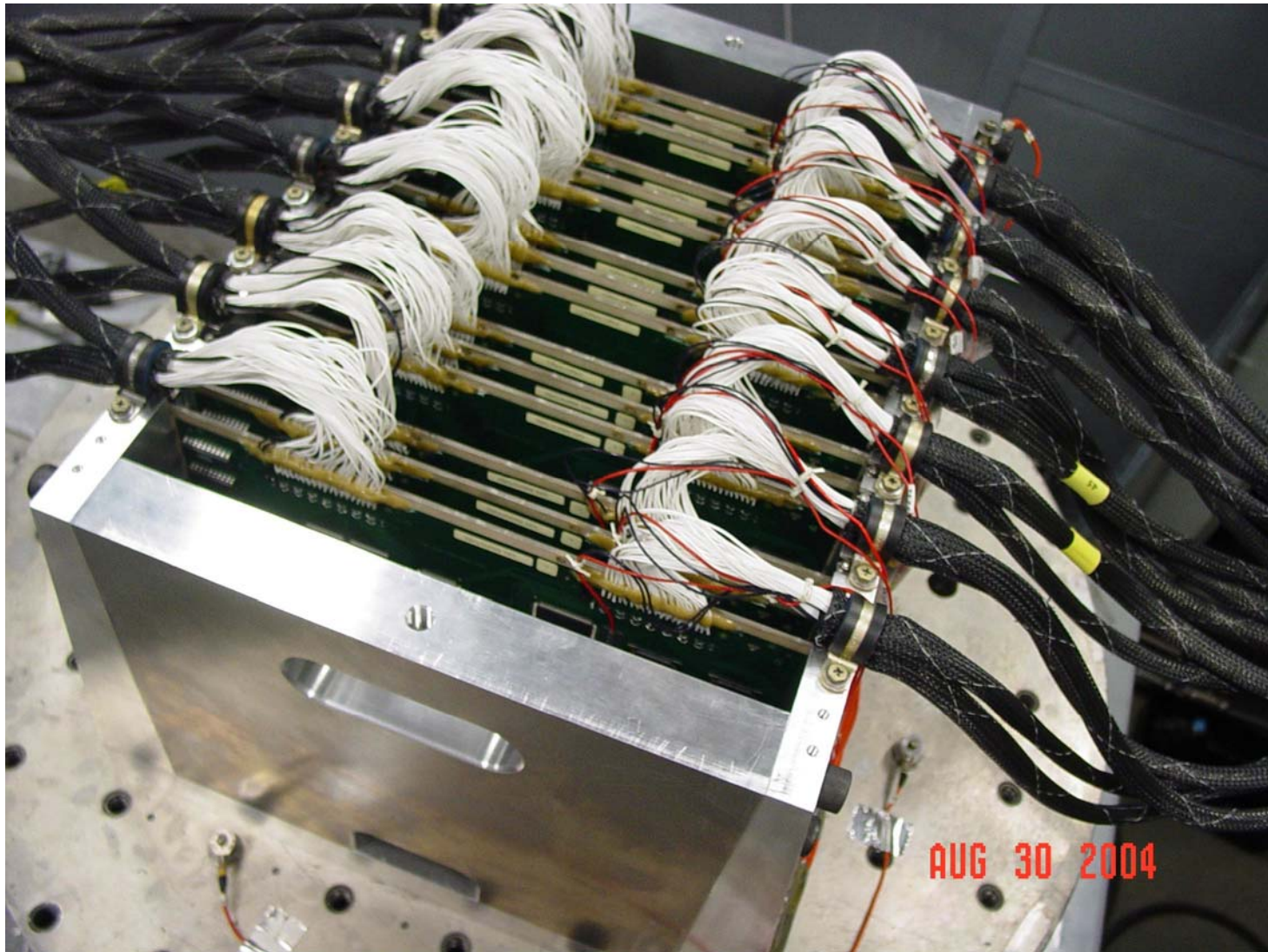


# Strain vs. Frequency

(the most strain is at 72 Hz)



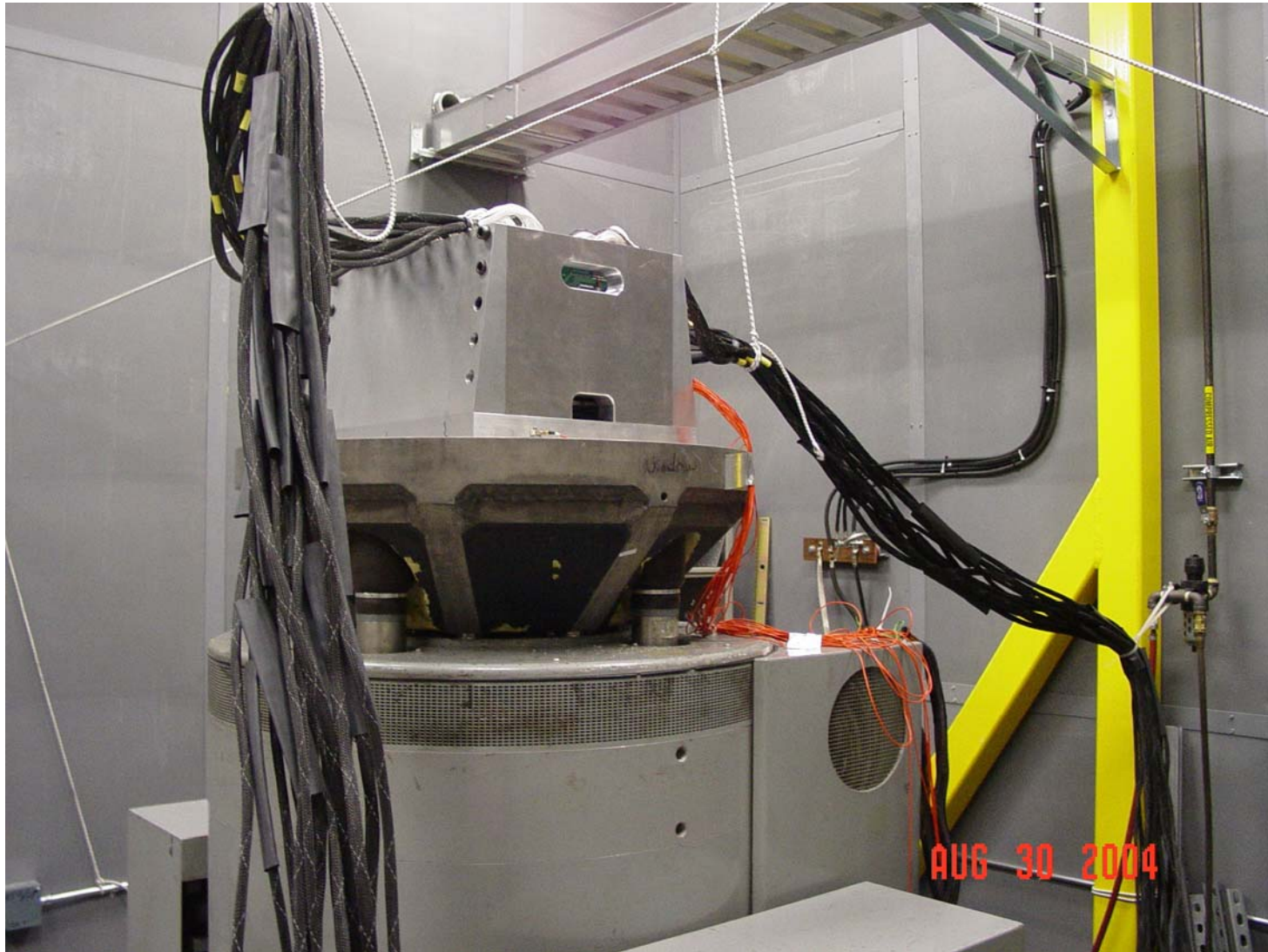
# Test Vehicles in Fixture



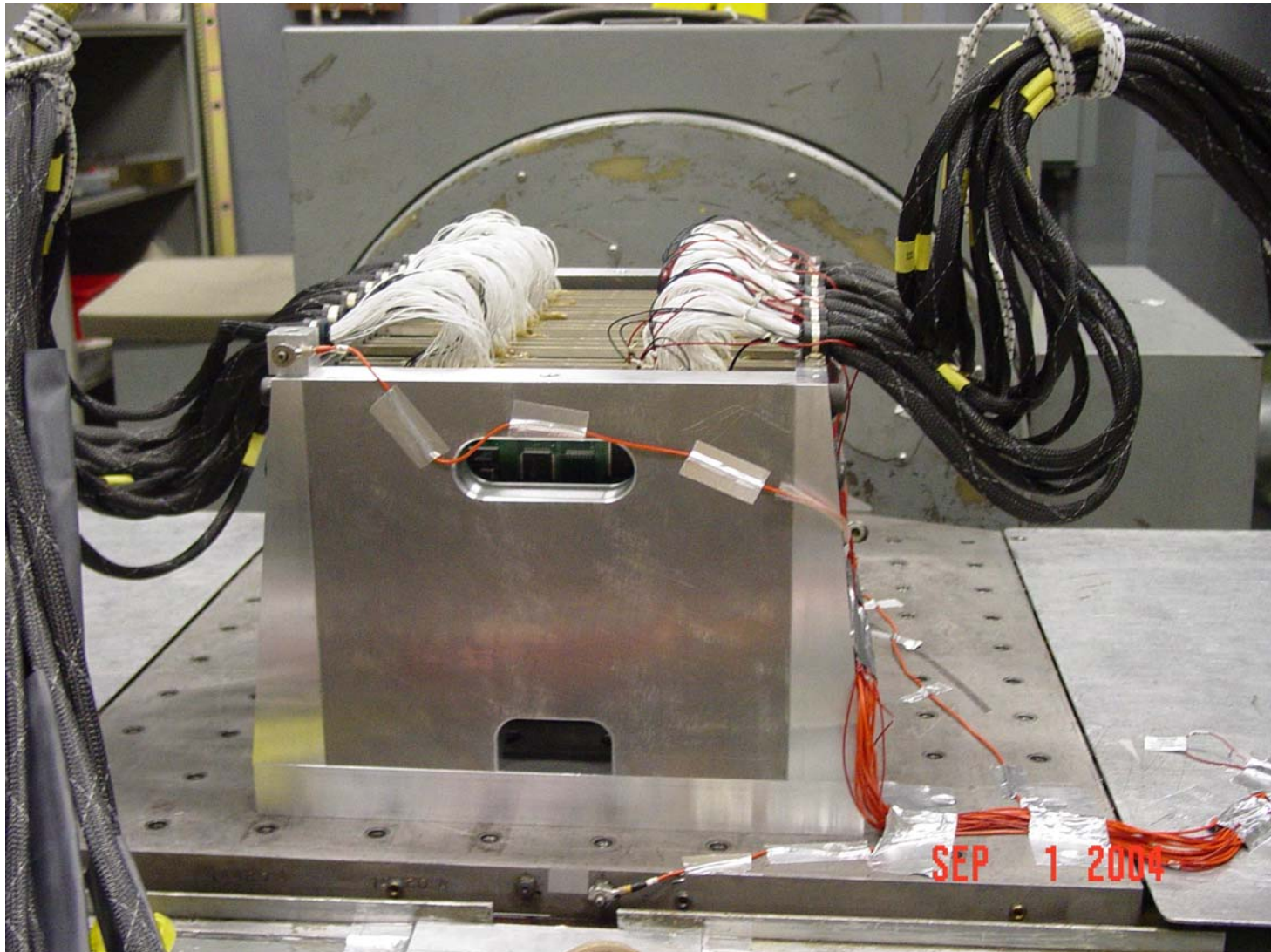
AUG 30 2004



# Vibration Table (Y-axis)

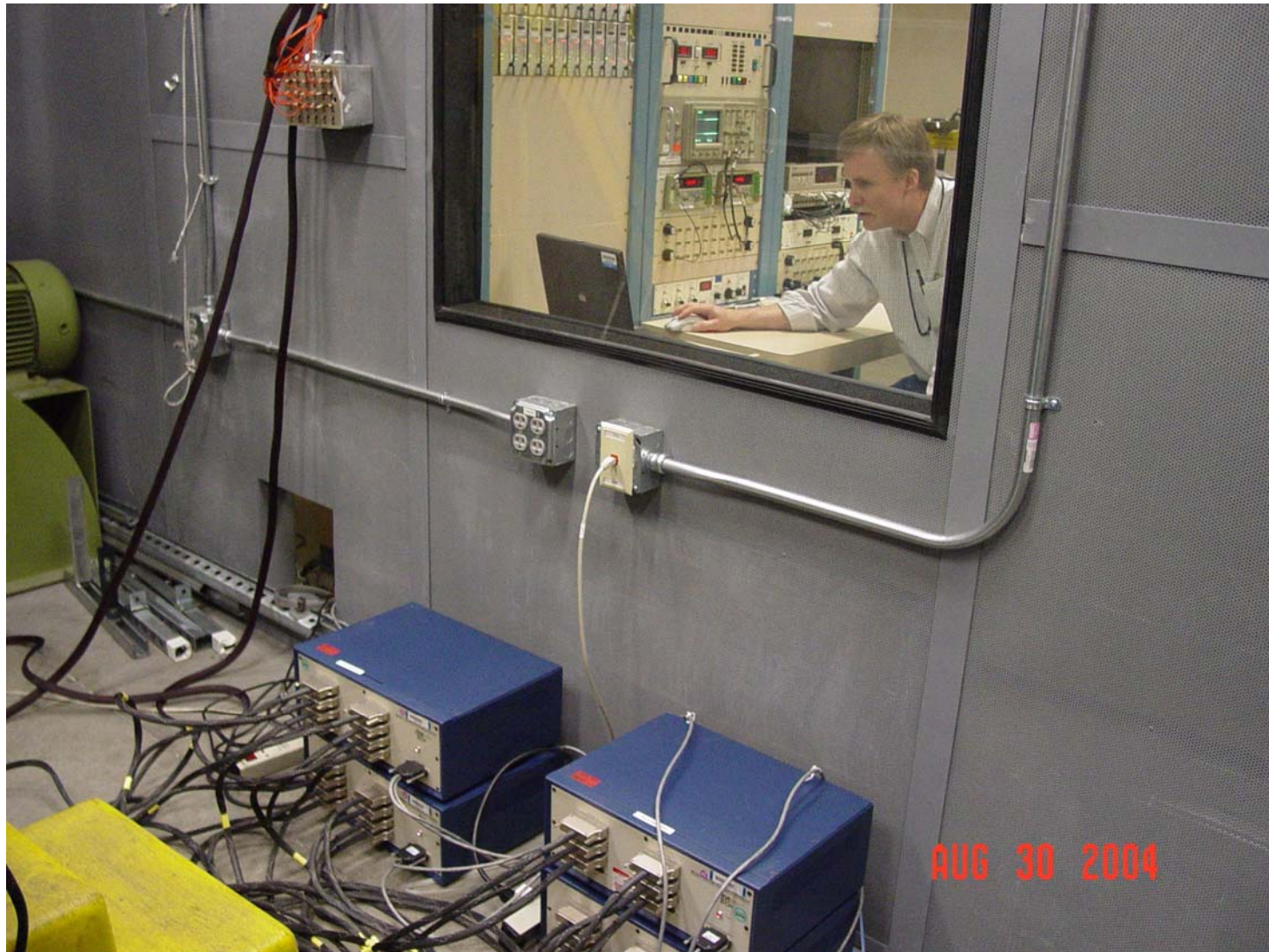


## Vibration Table (Z-axis)

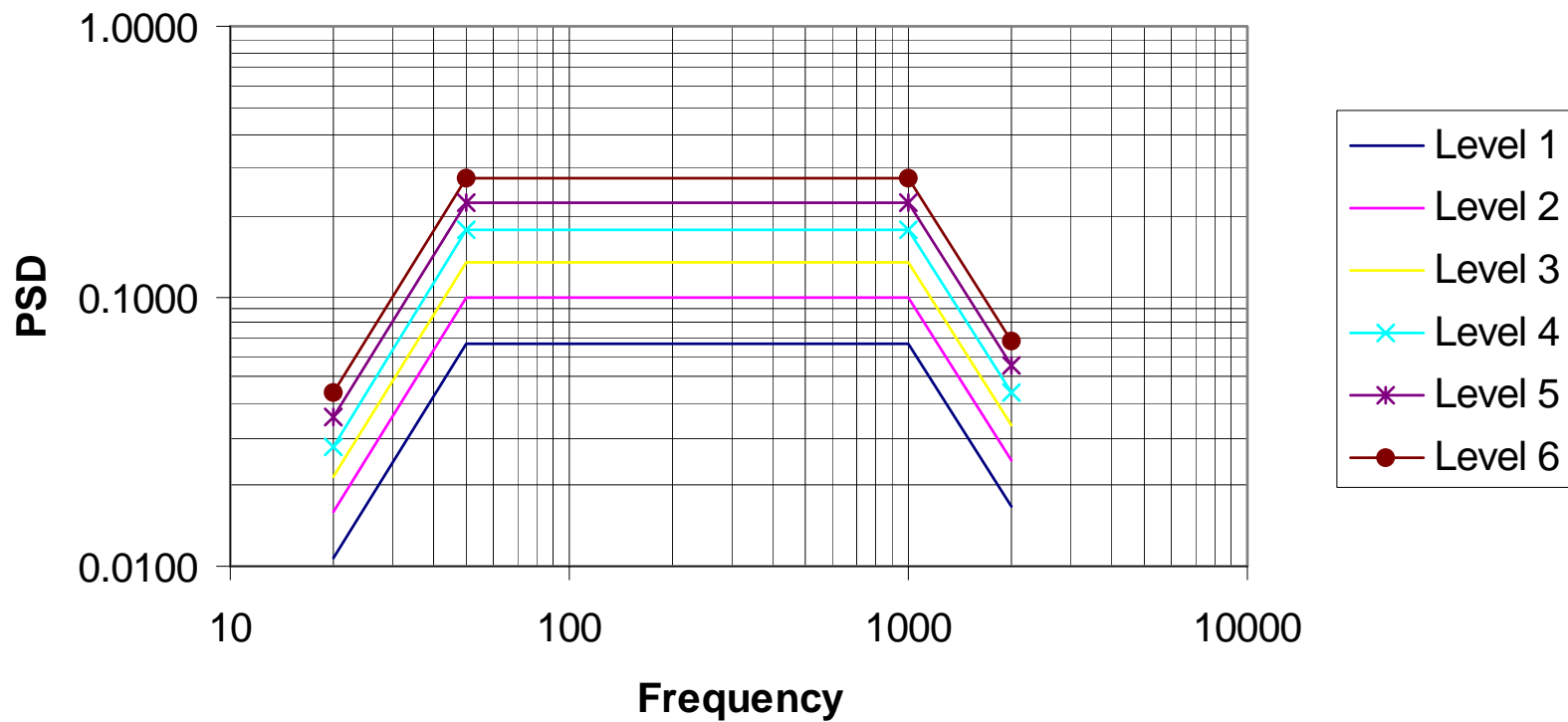




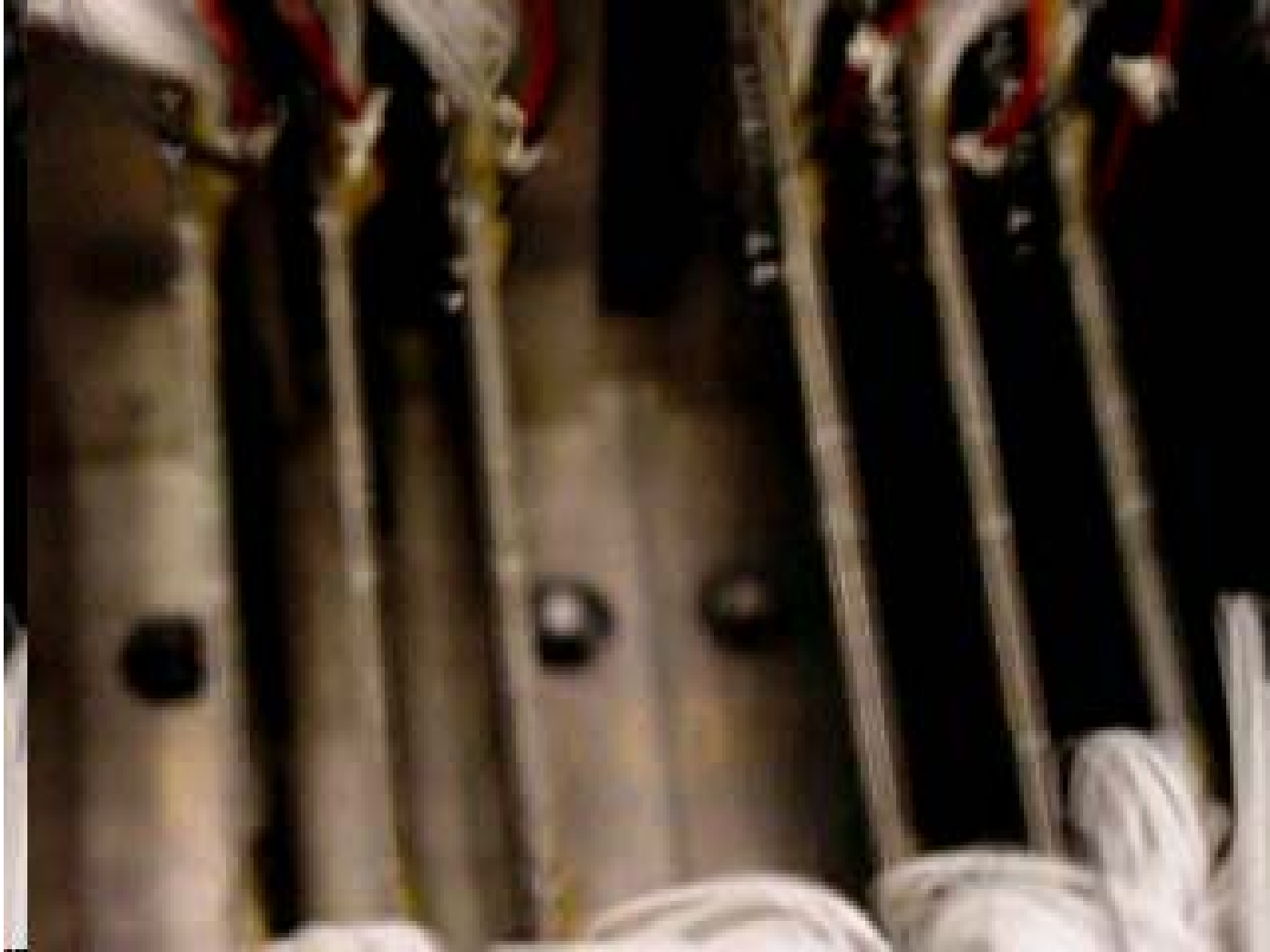
# Anatech Event Detectors



## Lead-free Alloy Solder Test Levels



## Test Vehicles in Z-Axis (20.0 Grms)





# Vibration Status

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- All “manufactured” and “rework” test vehicles have been tested
- Data needs to be reduced and put into a useable format

## U43 BGA (Manufactured Boards)

Test Vehicle ID	Solder/Finish	Time at Each Level (minutes)								
		Y-axis	X-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis	Z-axis
		9.9 Grms	9.9 Grms	9.9 Grms	12.0 Grms	14.0 Grms	16.0 Grms	18.0 Grms	20.0 Grms	28.0 Grms
79	SAC/SAC	60	60	5						
77	SAC/SAC	60	60	6						
75	SAC/SAC	60	60	10						
76	SAC/SAC	60	60	23						
78	SAC/SAC	60	60	60	10					
116	SACB/SAC	60	60	7						
114	SACB/SAC	60	60	16						
117	SACB/SAC	60	60	20						
115	SACB/SAC	60	60	32						
118	SACB/SAC	60	60	51						
6	SnPb/SnPb	60	60	54						
5	SnPb/SnPb	60	60	60	3					
8	SnPb/SnPb	60	60	60	16					
9	SnPb/SnPb	60	60	60	16					
7	SnPb/SnPb	60	60	60	20					

# Data Sharing

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- Vibration test data will be shared with the U of Maryland (CALCE)
- CALCE will use the test data to help validate their vibration fatigue computer models